

**Remarks/Arguments:**

Claims 1-8 are pending in the application.

Claims 1-3 and 5-8 stand rejected under 35 U.S.C. § 103(a) as unpatentable over U.S. Patent No. 4,481,106 ("Verachtert") in view of U.S. Patent No. 5,169,516 ("Carr") and U.S. Patent No. 5,463,134 ("Frey"). Claim 4 stands rejected under 35 U.S.C. § 103 (a) as unpatentable over Verachtert in view of Carr and Frey and U.S. Patent No. 3,839,192 ("Hayes"). Applicant traverses these rejections and respectfully submits that the currently pending claims are patentable over these cited references for at least the reasons set forth below.

**Features of the Claims**

Claim 1 is set forth below:

***A process for the separation of a stream containing propane and/or butanes from a natural gas liquid contaminated with alkyl mercaptans by fractional distillation at such a pressure that a separated overheads stream containing said propane and/or butanes is at a temperature in the range 50 to 100°C, comprising:***

***introducing sufficient oxygen into said natural gas liquid to oxidise the mercaptans therein and***

***subjecting the resultant mixture to the fractional distillation in a column including at least one bed of a catalyst capable, under the prevailing conditions, of oxidising mercaptans to higher boiling point sulphur compounds,***

***and separating the higher boiling point sulphur compounds as part of a liquid phase from the distillation.***

Applicant's invention, as recited in independent claim 1, therefore, is directed to catalytic oxidation of alkyl mercaptans in a fractional distillation column containing at least one bed of catalyst capable of oxidizing the mercaptans to higher boiling point sulphur compounds. The higher boiling point sulphur compounds are separated, as part of a liquid phase, from the overhead stream containing the propane and/or butanes. The distillation in the present invention is thus required to separate a stream containing propane and/or butanes from a contaminated natural gas liquid.

## Rejections

The Office rejects independent claim 1 as obvious over Verachtert in view of Carr and Frey. Specifically, the Office asserts that Verachtert discloses all of the features of Applicant's invention except for: (1) a feed stream containing propane and/or butanes from a natural gas liquid, (2) that the separation zone is a catalyst fractional distillation and (3) a temperature and pressure range.

To supply these features, the Office turns to Carr and Frey and routine skill in the art. The Office asserts that Carr discloses "a feed stream containing light liquid hydrocarbons in the C3-C5 range which contains mercaptan sulfur to be catalytically oxidized with air to convert mercaptans to disulfides." (Office Action, page 3). Thus, the Office alleges that it would have been obvious to one of ordinary skill in the art "to use the light liquid hydrocarbons as taught by Carr since it was known in the art to convert a "sour" natural gas into a "sweet" product using a catalytic oxidation process.

Further, the Office asserts that Frey discloses "a catalytic distillation column for removing the contaminants such as mercaptans, oxygenates and olefins . . . ." (Office Action, page 3). The Office alleges that it would have been obvious to one of ordinary skill in the art to "use the catalytic distillation column of Frey in place of the separation zone of Verachtert to reduce the size and complexity of the equipment needed and reduce the capital cost for removing the levels of mercaptans and olefinic hydrocarbons in the hydrocarbon stream . . . ." (Office Action, page 4).

The Office also relies on *In re Aller*, alleging that it would have been obvious to one of ordinary skill in the art to select a pressure and temperature range for the claimed distillation on the basis of merely discovering the optimum or workable ranges using routine skill.

## Response to Rejections

Contrary to the Office's assertions, Applicant submits that the combination of Verachtert, Carr and Frey fails to teach or suggest all of the features of Applicant's invention. Among the criteria for establishing a *prima facie* case of obviousness is that all of the claim limitations must be taught or suggested by the prior art. M.P.E.P. § 2143.03 (citing *In re Rozka*, 490 F.2d 981, 180 USPQ 580 (C.C.P.A. 1974)).

More specifically, Verachtert discloses a process for oxidizing mercaptans present in refinery hydrocarbons, such as naphtha, into disulphide compounds. The conversion of the mercaptans is effected during passage of the hydrocarbon and an aqueous stream downward through a cylindrical mass of liquid-liquid contact material. (See, Verachtert at abstract and reference numeral 6 in the Figure). The liquids then flow through a cylindrical screen into an annular separation zone which surrounds a lower part of the contact material. After decantation in the separation zone, the aqueous material, which preferably contains the oxidation catalyst, is recycled. In Verachtert, the disulphide oxidation products remain in the hydrocarbon. (See Verachtert at abstract and col. 1, lines 20-24).

Applicant submits that Verachtert does not disclose distillation to separate a stream containing propane and/or butanes from a contaminated natural gas liquid, nor that the distillation column should contain a catalyst effective for catalyzing the oxidation of mercaptans, as the Office acknowledges. Moreover, Verachtert also fails to disclose that the higher boiling point sulphur compounds generated by the oxidation should be separated as part of a liquid phase from the distillation.

In particular, Applicant submits that Verachtert discloses the use of an alkaline aqueous phase as the carrier for an oxidation catalyst and that, as a consequence, separation of the aqueous phase and catalyst from the hydrocarbon is required. (See Verachtert at col. 6, lines 4-35 and claim 1). Verachtert fails to contemplate oxidation and distillation as claimed, let alone distillation of a natural gas liquid, which one of ordinary skill in the art would recognize is not a refinery hydrocarbon as such. Accordingly, the invention as recited in claim 1 recites at least one additional feature not identified by the Office as being disclosed by Verachtert or either of the secondary references, namely, that the higher boiling point sulphur compounds generated by the oxidation should be separated as part of a liquid phase from the distillation.

Alternatively, Applicant submits that the Office's reliance on the combination of Verachtert, Carr and Frey is also flawed. This is because Verachtert promotes the use of an alkaline aqueous phase, which is immiscible with the hydrocarbon phase, in order to contact the hydrocarbon with an oxidation catalyst. Indeed, whereas in Verachtert the oxidation catalyst "may be supported on a bed of inert solids in the oxidation zone," this is less preferred and Verachtert teaches that the catalyst is preferably dispersed in the aqueous phase. (See Verachtert at col. 6, lines 36-42). Thus, rather than lead one of ordinary skill in the art to

combine Verachtert with Carr and Frey, Verachtert instead leads one of ordinary skill in the art away from the combination of Verachtert, Carr and Frey.

Carr discloses a process for removing arsenic and mercaptan sulphur compounds from a hydrocarbon stream using a particular arrangement of oxidation and sorbent vessels. Whereas the hydrocarbon stream may be liquefied petroleum gas (LPG) or light liquid hydrocarbons (see col. 1, lines 18-21), the feed is clearly naphtha. (See e.g., Carr at col. 3, line 41; col. 4, lines 49-64; and examples). Furthermore, in Carr, the hydrocarbon feed is merely passed through two sequential oxidation vessels, 16 and 26, containing oxidation catalyst, 18 and 28, that oxidize a high portion of the mercaptans. Unlike Verachtert, aqueous caustic is only used intermittently and is not used to carry the oxidation catalyst. (Carr at col. 12, lines 44-46). Here again, the mercaptans are not separated from the hydrocarbon, merely converted to disulphides. The resulting hydrocarbon containing the disulphides and any non-mercaptan sulphur compounds is passed over the arsenic sorbent to provide a product suitable for a naphtha steam cracking process. (Carr at col. 3, lines 25-42).

Applicant submits, therefore, that Carr does not disclose distillation to separate a stream containing propane and/or butanes from a contaminated natural gas liquid, nor that the distillation column should contain a catalyst effective for catalyzing the oxidation of mercaptans, nor that the higher boiling point sulphur compounds generated by the oxidation should be separated as part of a liquid phase from the distillation. Moreover, the combination of Verachtert and Carr still requires the use of an alkaline aqueous phase and separation of the aqueous and hydrocarbon phases.

Applicant submits that there is no teaching in Verachtert or Carr to suggest changing the liquid phase separation processes described therein to a catalytic distillation process that separates propane and butanes from a mercaptans-contaminated natural gas liquid. Nor does Frey form a basis for supplying these features. Rather, Frey discloses a catalytic distillation of paraffinic feed stream using an acid catalyst, such as sulphonated resin, where mercaptans are reacted with olefins to form thioethers. (See e.g. Frey at col. 3, lines 28-35 and col. 4, lines 54-57). Applicant submits that Frey thus fails to disclose the catalytic oxidation of mercaptans. Moreover, the presence of olefins in the feed of Frey requires that an oxygen-free route be used. As discussed in Applicant's previous response with respect to the presence of diolefins in the Hearn reference (U.S. Patent No. 5,595,634), the olefins of Frey, like the diolefins of Hearn,

react with oxygen to form gums. Gums, however, are undesirable because they can block distillation apparatus. (See e.g. Hearn at col. 5, lines 4-6).

In contrast, natural gas is, and hence natural gas liquids are, "predominantly saturated." (See present application at page 1, line 4). In the process of the present invention, therefore, the addition of oxygen as required in claim 1 does not present the difficulties with gum formation, in contrast to the process of Frey. Moreover, Frey does not use aqueous caustic (alkaline solution), a requirement in both Verachtert and Carr. (See Frey at col. 2, lines 21-25).

Based on at least the above, Frey combined with Verachtert and Carr, therefore, would be incompatible and render Verachtert and Carr unfit for their intended purposes, if combined as the Office proposes. That is, the modification of Verachtert and Carr with Frey that the Office proposes would result in the formation of gums causing blockage in the distillation column. For at least the reasons that both Verachtert and Carr require oxygen and aqueous alkaline solution to be added to the hydrocarbon, one of ordinary skill in the art would not combine Frey with Verachtert and/or Carr.

Accordingly, Applicant submits that the Office has failed to establish a *prima facie* case of obviousness. Applicant submits, therefore, that claim 1 is patentable over the combination of Verachtert, Carr and Frey. Furthermore, claims 2-8 are patentable over Verachtert, Carr and Frey for at least the reasons that claim 1, from which they depend, is patentable, but may be separately patentable for additional reasons as well.

Notwithstanding the above, claim 4, which stands rejected as obvious over Verachtert in view of Carr, Frey and Hayes, is also patentable over these references for at least the reasons that claim 1 is patentable. Moreover, Hayes is merely cited for the feature of the catalyst being a granular material comprising copper sulphates, sodium chloride and water on a clay support. Applicant submit that Hayes fails to make up for the deficiencies of Verachtert, Carr and Frey, as set forth above. Claim 4 is, therefore, patentable over Verachtert in view of Carr, Frey and Hayes.

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## Conclusion

In view of the arguments as set forth above, Applicant submits that the currently pending application is in condition for allowance. Notice to this effect is earnestly solicited.

Respectfully submitted,



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